Coupled Regional Ocean Atmosphere Model (CROAM)

User Manual

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There are many coupled ocean-atmosphere models out there, this is one of them. CROAM uses the Weather Forecasting Research (WRF) model for the atmospheric component and the Regional Ocean Modeling Systems (ROMS) as the oceanic component. Such coupling between the 2 models have been done before, including the UCLA WRF-ROMS model, and COAWST. CROAM is inspired from SCOAR (Scripps Coupled Ocean Atmosphere Regional) model. It uses the idea of placing a SST-flux coupler to couple the two models.

For this version of CROAM, we use WRF version 3.1 and ROMS version 3.0.
For help with WRF, you can refer to http://www.mmm.ucar.edu/wrf/users/docs/user_guide_V3/contents.html.
For help with ROMS, you can refer to https://www.myroms.org/wiki/index.php/Documentation_Portal

This manual shows how to install, set it up and run a simple case.

Check that you have C compiler, Fortran90 compiler and adequate space in your system. Other programs and toolbox you may want to have for verification purposes and/or to prepare the files before running the coupled model would include Matlab(R), ROMS toolbox (IRD and Manu's toolbox), GrADS, ncview, nco, WPS (WRF Preprocessing System).

For the purposes of this manual, the colors are coded as follows:
Red is for emphasis
Blue for commands in unix/linux environment
Brown for commands/statements in vi editor
Green for commands in Matlab or GrADS
Black for normal text or comments
Some file edits in vi mode are in black for easier reading with indentations.

Let's set up and place CROAM in a directory called Coupled_WrfRoms. There are 6 main folders

for CROAM (Lib/, Model/, Run/, Shell/, Log/, Info/).

- Lib/ contains any auxiliary files, codes for the coupler, all executable files, all grid preparation files and some utilities that would help for the coupler. An extra folder for grib2 libraries can be added if you want to use grib2 format data.
- Model/, as it the name suggests, holds all the source code for ROMS, WRF and WPS.
- Shell/ contains all the shell scripts for calling each executable at the appropriate times.
- Log/ keeps all the standard outputs that come from running the shell scripts.
- Info/ stores the geographic data for WRF, template files for ROMS, and data set used in WPS for preparing WRF.
- Once CROAM starts running, everything is placed and carried out in the Run/ folder.

```
mkdir Couple_WrfRoms
cd Couple_WrfRoms
mkdir Lib/ Model/ Run/ Shell/ Log/ Info/
cd Lib
mkdir aux-files/ codes/ exec/ grids/ utils/ GRIB2LIBS/
cd exec
mkdir Coupler/ ROMS/
cd ../../Model
mkdir ROMS/ WRFV3/ WPS/
cd ../Shell
mkdir main_couple
cd ../Info
mkdir geog/ templates/ WRFdata/
```

1. Download and Installation

Check that netcdf has been installed. If not, go to http://www.unidata.ucar.edu/software/netcdf/ and download netcdf-version.tar file.

```
tar xvf netcdf-3.6.1.tar
cd netcdf-3.6.1/src
./configure –prefix=/home/username/netcdf/
make check
make install
```

Set environment for NETCDF, example

```
vi ~/.tcshrc
 setenv NETCDF /home/user/ROMS/NetCDF/netcdf-3.6.1
```

a. WRF

There are several ways to get hold of WRF. The method used here is one of them. WRFV3 (version3) can be downloaded from http://www.mmm.ucar.edu/wrf/users/downloads.html . However, you would need to register in order to get the downloads.

- Download WRFv3.tar.gz and place them in ~/Couple_WrfRoms/Model
  cd ~/Couple_WrfRoms/Model
  gunzip WRFv3.tar.gz
  tar xvf WRFv3.tar
- Set your environment for WRF and source it.
  vi ~/.tcshrc
  setenv WRF_EM_CORE 1
  setenv WRF_NMM_CORE 0
  setenv WRF_DA_CORE 0
  setenv WRFIO_NCD_LARGE_FILE_SUPPORT 1
  #setenv OMP_NUM_THREADS 32
  #setenv MP_STACK_SIZE 64000000
  source ~/.tcshrc
- Configure and compile WRF
  cd ~/Couple_WrfRoms/Model/WRFV3
  ./configure
  Choose appropriate compiler option and nesting capability.
  Any edits can be done on configure.wrf and arch/confgiure_new.defaults, which provides compile options and rules for computer compiling.
  ./compile em_real >& compile_emreal.log
  Check that we have real.exe, wrf.exe.nup.exe, ndown.exe in main/ . Note that "clean -a" is an option for "make clean"
- Check node list in home directory then copy over
  cd
  vi nodelist
  cp ~/node_list ./

b. WPS

WPS is also downloaded from http://www.mmm.ucar.edu/wrf/users/downloads.html .

- Download WPS.tar.gz and place them in ~/Couple_WrfRoms/Model
  cd ~/Couple_WrfRoms/Model
  gunzip WPS.tar.gz

tar xvf WPS.tar

- Download terrestrial data from www.mmm.ucar.edu/wrf/users/download/get_source.html . Check under download tab, then put in login.
  cd ~/Couple_WrfRoms/Info/geog
  gunzip geog_v3.1.tar.gz
  tar xvf geog_v3.1.tar
- If you intend to use grib format data, particularly GRIB2, you'll need to download the necessary libraries from http://www.mmm.ucar.edu/wrf/OnLineTutorial/Compile/wps_compile2.htm
  Download libs_for_wps.tar, libpng-1.2.12.tar.bz2, zlib-1.2.3.tar.bz2, jasper-1.701.0.zip, and place them all in ~/Couple_WrfRoms/Lib/GRIB2LIBS
  cd ~/Couple_WrfRoms/Lib/GRIB2LIBS
  tar xvf libs_for_wps.tar
  tar -xvjf libpng-1.2.12.tar.bz2
  tar -xvjf zlib-1.2.3.tar.bz2
  unzip jasper-1.701.0.zip
  Configure and install each library
  cd zlib-1.2.3/
  ./configure –prefix=~/Couple_WrfRoms/Lib/GRIB2LIBS/zlib-1.2.3
  make test
  make install prefix=~/Couple_WrfRoms/Lib/GRIB2LIBS/zlib-1.2.3
  cd ../libpng-1.2.12/
  ./configure –prefix=~/Couple_WrfRoms/Lib/GRIB2LIBS/libpng-1.2.12
  make check
  make install prefix=~/Couple_WrfRoms/Lib/GRIB2LIBS/libpng-1.2.12
  cd ../jasper-1.701.0/
  ./configure –prefix=~/Couple_WrfRoms/Lib/GRIB2LIBS/jasper-1.701.0
  make check
  make install prefix=~/Couple_WrfRoms/Lib/GRIB2LIBS/jasper-1.701.0
  Set the environments for these libraries and source it.
  vi /.tcshrc
  set LD_LIBRARY_PATH=(~/Couple_WrfRoms/Lib/GRIB2LIBS/libpng-1.2.12/lib ~/Couple_WrfRoms/Lib/GRIB2LIBS/zlib-1.2.3/lib/)
  setenv JASPERLIB ~/Couple_WrfRoms/Lib/GRIB2LIBS/jasper-1.701.0/lib
  setenv JASPERINC ~/Couple_WrfRoms/Lib/GRIB2LIBS/jasper-1.701.0/include
  source ~/.tcshrc
- Configure WPS and this would create configure.wps file
  cd ~/Couple_WrfRoms/Model/WPS
  ./configure

- Compile WPS
  vi configure.wps
  COMPRESSION_LIBS = -L~/Couple_WrfRoms/Lib/GRIB2LIBS/jasper-1.701.0/lib -ljasper \
  -L~/Couple_WrfRoms/Lib/GRIB2LIBS/libpng-1.2.12/lib -lpng -lpng12 \
  -L~/Couple_WrfRoms/Lib/GRIB2LIBS/zlib-1.2.3/lib -lz
  COMPRESSION_INC = -I~/Couple_WrfRoms/Lib/GRIB2LIBS/libpng-1.2.12/include \
  -I~/Couple_WrfRoms/Lib/GRIB2LIBS/zlib-1.2.3/include \
  -I~/Couple_WrfRoms/Lib/GRIB2LIBS/jasper-1.701.0/include
  ./clean
  ./compile >& compile_wps.log
  Check to see if geogrid.exe, ungrib.exe and metgrid.exe are created.
  Check in util/ : avg_tsfc.exe, g1print.exe, g2print.exe, mod_levs.exe, rd_intermediate.exe, calc_ecmwf_p.exe
  If NCAR graphics are there, gplotgrids.exe and plotfmt.exe

c. ROMS

In order to download ROMS, you would need to register with the ROMS community (http://www.myroms.org/). Once you have a username and password, ROMS maybe downloaded using SVN.

- svn checkout –username <username> https://www.myroms.org/svn/src/trunk ~/Couple_-WrfRoms/Model/ROMS/
  Authentication realm: <https://www.myroms.org:443> Subversion Repository
  Password for <username>
- Type in your password and download of ROMS will commence.
  Directories created: Atmosphere/, Compilers/, Data/, Lib/, Master/, ROMS/, .svn/, User/, Waves/, makefile
- Ensure that your netcdf path and mpif90 location is correct.
  cd Compilers
  vi Linux-pgi.mk
  ifdef USE_NETCDF4
  NETCDF_INCDIR ?= /opt/pgisoft/netcdf4/include
  NETCDF_LIBDIR ?= /opt/pgisoft/netcdf4/lib
  HDF5_LIBDIR ?= /opt/pgisoft/hdf5/lib
  else
  NETCDF_INCDIR ?= /share/apps/netcdf/pgi/include
  NETCDF_LIBDIR ?= /share/apps/netcdf/pgi/lib
  endif

ifdef USE_MPIF90
FC := /share/apps/mpich1/pgi/bin/mpif90
LD := $(FC)
else
LIBS += -Bdynamic -lfmpi-pgi -lmpi-pgi -Bstatic
endif

- Turn on MPI and 64-bit setting
  cd ..
  vi makefile
  USE_MPI ?= on
  USE_MPIF90 ?= on
  USE_LARGE ?= on
  make

d. Coupler

Need to copy over shell scripts, coupler code, utilities and auxiliary files. Compile the codes and utilities.

- cd ~/Couple_WrfRoms/Shell
  scp user@home.comp:~/Research/CROAM/020711_croam_scripts.tar ./
  tar xvf 020711_croam_scripts.tar
  mv main_couple.sh main_couple/
- cd ~/Couple_WrfRoms/Lib/aux-files
  scp user@home.comp:~/Research/CROAM/Lib/croam_auxfiles.tar ./
  tar xvf croam_auxfiles.tar
- cd ../codes
  scp user@home.comp:~/Research/CROAM/Lib/croam_libcodes.tar ./
  tar xvf croam_libcodes.tar
  Make sure path and directories in compile_code.sh are correct, then compile.
  compile_code.sh
- cd ../utils
  scp user@home.comp:~/Research/CROAM/Lib/croam_utils.tar ./
  tar xvf croam_utils.tar
  Edit path to ftpscr in fetchfile and putfile.
  vi fetchfile
  ~/Couple_WrfRoms/Lib/utils/ftpscr
  vi putfile
  ~/Couple_WrfRoms/Lib/utils/ftpscr

Make sure path and directories in compile_utils.sh are correct, then compile.
compile_utils.sh
Set path in linux environment to see utils folder and source it
vi ~/.tcshrc
set path=($path ~/dputrasa/Couple_WrfRoms/Lib/utils)
source ~/.tcshrc

2. Grid Set-up

The domain is to be created in WPS/WRF first. For the purpose of this study, let's take the case for the Gulf of Mexico. We'll use the exact same grid on ROMS. This way, no interpolation between grids needs to be done.

a. I) Setting up domain in WPS (LINUX MACHINE)

For the Gulf of Mexico set up, we will use the case name (grid name) "gom". Nesting is NOT used in this case. The domain will have a 30km horizontal resolution, with (74 x 74) grid points.
WPS is a 3 step processing program to create the grid file, initial and boundary conditions, as well as SST forcing. To create the grid file, we only need to deal with geogrid.exe for now.

- Create case folders to set up grid
  cd ~/Couple_WrfRoms/Model/WPS
  mkdir gom
  cd ~/Couple_WrfRoms/Model/WRFV3/test/em_real
  mkdir gom
- Edit namelist.wps
  cd ~/Couple_WrfRoms/Model/WPS
  vi namelist.wps

```
&share
 wrf_core = 'ARW',
 max_dom = 1,
 start_date = '2010-01-15_00:00:00'
 end_date   = '2010-01-20_00:00:00'
 interval_seconds = 21600
 io_form_geogrid = 2,
 opt_output_from_geogrid_path = '~/Couple_WrfRoms/Model/WPS/gom',
&geogrid
 parent_id         =   1,
 parent_grid_ratio =   1,
```

```
i_parent_start    =   1,
j_parent_start    =   1,
e_we              =  74,
e_sn              =  74,
geog_data_res     = '10m'
dx = 30000,
dy = 30000,
map_proj = 'mercator',
ref_lat   =  25.00,
ref_lon   = -90.00,
truelat1  =   0.0,
truelat2  =  60.0,
stand_lon = -98.0,
geog_data_path = '~/Couple_WrfRoms/Info/geog'
```

- Check that GEOGRID.TBL is linked to GEOGRID.TBL.ARW in geogrid/, then create grid file
  ls -lahtr geogrid
  geogrid.exe >& gom/geogridtbl.log
  mv geogrid.log gom/geogrid.log
  To check the grid, you can use ncview.
  ncview gom/geo_em.d01.nc

b. II) Setup domain in ROMS (local computer)

Here we create grid.nc files. Note that grdname must NOT contain "-" for the region part. This is part of the preparation for ROMS spin up run. We will use a mix of ROMS toolboxes (IRD toolbox and Manu's toolbox).

- Set parameters and file names
  cd ~/ROMS/IRD_toolbox/Roms_tools
  cp -r Preprocessing_tools/ Preprocessing_tools_test/
  cd !$
  mkdir gom
  cp romstools_param.m gom/romstools_param_gom.m
  cd gom
  scp user@comp.cluster:~/Couple_WrfRoms/Model/WPS/gom/geo_em.d01.nc ./
  vi romstool_param_gom.m
  title = 'Gulf of Mexico - Ocean Spin Up ';
  config = 'gom';
  nc=netcdf('~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom/geo_em.d01.nc');

```
lat=nc'XLAT_M'(:);
lon=nc'XLONG_M'(:);
close(nc); clear nc
latr=lat(:,1)';
lonr=lon(1,:);
clear lat lon
N=30;
theta_s=6.5;
theta_b=0.;
hc=10.;
hmin=75;
rtarget = 0.2;
obc = [1 1 0 0]; % open boundaries (1=open , [S E N W])
cp romstools_param_gom.m ../romstools_param.m
cd ..
vi make_grid.m
grdname='gom-grid.nc';
vi make_forcing.m
title=['Forcing (COADS)'];
grdname='gom-grid.nc';
frcname='gom-forc.nc';
vi make_clim.m
title='Climatology';
grdname='gom-grid.nc';
frcname='gom-forc.nc';
clmname='gom-clim.nc';
ininame='gom-init.nc';
oaname='gom-oa.nc';
```

- Preparing the files using matlab.

```
matlab
make_grid
close all
make_forcing
close all
make_clim
close all
exit
mv gom*.nc gom/
```

- Set information of grids in rnt_gridinfo.m . This is to ensure that matlab would search for

the right grid files.

```
cd ~/ROMS/Manu_toolbox/matlib/rnt/
vi rnt_gridinfo.m
case 'gom'
gridindo.id = gridid;
gridindo.name = 'GOM Spinup 30km';
gridindo.grdfile = '~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom/gom-grid.nc';
gridindo.N = 30;
gridindo.thetas = 6.5;
gridindo.thetab = 0.0;
gridindo.tcline = 75;
gridindo.hc = 10;
gridindo.cstfile = '~/ROMS/Manu_toolbox/matlib/rgrd/rgrd_WorldCstLinePacific.mat';
```

- Create climatology, boundary and initial files for ROMS spin up run.

```
cd ~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test
matlab
grd=rnt_gridload('gom');
indir="~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom';
nameof='gom';
clmfile=[indir,nameof,'-clim.nc'];
bryfile=[indir,nameof,'-bry.nc'];
initfile=[indir,nameof,'-init.nc'];
forcfile=[indir,nameof,'-forc.nc'];
rnc_CreateBryFile(grd,bryfile);
rnc_SetBryFromClim(grd,clmfile,bryfile);
rnc_CreateIniFile(grd,initfile);
% If you want to set initial month to January,
imon=1;
rnc_SetInitFromClim(grd,clmfile,initfile,imon);
exit
```

3. ROMS spin-up

A spin-up for the ocean model is required in order for the ocean state to be stable. Typically, we would give it a 10 year spin-up run. The atmosphere itself only requires about 2 days for spin up.

- Create folder for ROMS application (LINUX machine)

```
cd ~/Couple_WrfRoms/Model/ROMS/
mkdir spinup_gom
```

- Modify makefile provide a name for ROMS application
  vi makefile
  ROMS_APPLICATION ?= SPINUP_GOM
- Create "apps.h" file to specify all the definitions for the ROMS application. Listing of definitions that can be used are located in ~/Couple_WrfRoms/Model/ROMS/ROMS/Include/cppdefs.h. Many examples of "apps.h" are located in the same folder. Below is a sample for this case study. If you want to ROMS to have a sponge layer, SCOAR manual will show an example of how this is done.
  cd ROMS/Include
  vi spinup_gom.h
  #define NL_MODEL
  #ifdef NL_MODEL
  #undef ADJOINT
  #undef TANGENT
  #endif
  #define UV_ADV
  #define UV_COR
  #define UV_VIS2
  #define UV_LDRAG
  #undef MIX_GEO_UV
  #define MIX_S_UV
  #define TS_U3HADVECTION
  #define TS_C4VADVECTION
  #define TS_DIF2
  #undef TS_DIF4
  #undef MIX_GEO_TS
  #define MIX_S_TS
  #define DJ_GRADPS
  #define SALINITY
  #define QCORRECTION
  #define SCORRECTION
  #define NONLIN_EOS
  #define CURVGRID
  #define MASKING
  #define SOLVE3D
  #define SPLINES
  #define OUT_DOUBLE
  #define AVERAGES
  #define AVERAGES_FLUXES

```
#ifdef NL_MODEL
#define LMD_MIXING
#undef MY25_MIXING
# ifdef LMD_MIXING
# undef DIURNAL_SRFLUX
# define SOLAR_SOURCE
# define LMD_RIMIX
# define LMD_CONVEC
# define LMD_NONLOCAL
# define LMD_SKPP
# endif
#else
#undef LMD_MIXING
#endif
#undef CLIM_NUDGING
#undef CLOSED_OBC
#ifndef CLOSED_OBC
#undef EASTERN_WALL
#define NORTHERN_WALL
#undef SOUTHERN_WALL
#define WESTERN_WALL
#endif
#define CLAMPED_BC
#ifdef CLAMPED_BC
# define SOUTH_FSCHAPMAN
# define SOUTH_M2FLATHER
# define SOUTH_M3CLAMPED
# define SOUTH_TCLAMPED
# define EAST_FSCHAPMAN
# define EAST_M2FLATHER
# define EAST_M3CLAMPED
# define EAST_TCLAMPED
#else
# define SPONGE
# define ......
#endif
#define ANA_BSFLUX
#define ANA_BTFLUX
```

Since we use clamped conditions, we won't be using sponge layers for this case. So there's no

need to edit ROMS/Functionals/ana_hmixcoef.h for now. Check SCOAR manual to see how you could invoke the sponge layers.

- Now to make the ROMS executable file, oceanM will be created in ~/Couple_WrfRoms/Model/ROMS/
  cd ../..
  make
- Create input file (ocean_spinupgom.in) to ensure that ROMS takes in all the right values, according the the domain, model and cpu specifications. Myriad examples can be found in ~/Couple_WrfRoms/Model/ROMS/ROMS/External/ . Take one for them and modify accordingly.
  cd ~/Couple_WrfRoms/Model/ROMS/spinup_gom
  cp ~/Couple_WrfRoms/Model/ROMS/ROMS/External/ocean_upwelling.in ./ocean_spinupgom.in
  vi ocean_spingom.in
  TITLE = Gulf of Mexico
  MyAppCPP = SPINUP_GOM
  VARNAME = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/varinfo.dat

  Lm == 71 ! Number of I-direction INTERIOR RHO-points
  Mm == 71 ! Number of J-direction INTERIOR RHO-points
  N == 30 ! Number of vertical levels

  NtileI == 8 ! I-direction partition
  NtileJ == 8 ! J-direction partition

  NTIMES == 518400
  DT == 600.0d0
  NDTFAST == 30

  LDEFOUT == T
  NHIS == 4320
  NDEFHIS == 51840
  NTSAVG == 1
  NAVG == 4320
  NDEFAVG == 51840

  TNU2 == 20.0d0 20.0d0 ! m2/s
  TNU4 == 0.0d0 0.0d0 ! m4/s
  VISC2 == 5.0d0 ! m2/s
  VISC4 == 0.0d0 ! m4/s

BLK_ZQ == 2.0d0 ! air humidity
BLK_ZT == 2.0d0 ! air temperature

THETA_S == 6.5d0 ! 0 < THETA_S < 20
THETA_B == 0.0d0 ! 0 < THETA_B < 1
TCLINE == 75.0d0 ! m

DSTART = 15.0d0 ! days
TIDE_START = 0.0d0 ! days
TIME_REF = -1.0d0 ! yyyymmdd.dd

TNUDG == 30.0d0 30.0d0 30.0d0 30.0d0 30.0d0 30.0d0 ! days
ZNUDG == 30.0d0 ! days
M2NUDG == 30.0d0 ! days
M3NUDG == 30.0d0 ! days

OBCFAC == 10.0d0 ! nondimensional
GAMMA2 == -1.0d0

GRDNAME == spinup_gom/gom-grid.nc
ININAME == spinup_gom/gom-init.nc
CLMNAME == spinup_gom/gom-clim.nc
BRYNAME == spinup_gom/gom-bry.nc

NFFILES == 1 ! number of forcing files
FRCNAME == spinup_gom/gom-forc.nc ! forcing file 1, grid 1
RSTNAME == spinup_gom/rst.nc
HISNAME == spinup_gom/his.nc
AVGNAME == spinup_gom/avg.nc

APARNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/s4dvar.in
SPOSNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/stations.in
FPOSNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/floats.in
BPARNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/bioFasham.in
SPARNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/sediment.in
USRNAME = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/MyFile.dat

- Transfer of files from home computer to cluster (home computer)
  cd ~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom

scp gom-grid.nc user@comp.cluster:~/Couple_WrfRoms/Model/ROMS/spinup_gom/.
scp gom-forc.nc user@comp.cluster:~/Couple_WrfRoms/Model/ROMS/spinup_gom/.
scp gom-init.nc user@comp.cluster:~/Couple_WrfRoms/Model/ROMS/spinup_gom/.
scp gom-bry.nc user@comp.cluster:~/Couple_WrfRoms/Model/ROMS/spinup_gom/.

- Initiate spin up run of ROMS (LINUX machine)
  cd ~/Couple_WrfRoms/Model/ROMS/
  cp spinup_gom/ocean_spinupgom.in ./
  vi launch64
  /share/apps/mpich1/pgi/bin/mpirun -nolocal -np 64 -machinefile node_list oceanM ocean_spinupgom.in
  launch64 >& 1spinupgom.log

4. Files containing grid information for ROMS and WRF

- Create folders to place grid info files of ROMS and WRF (local machine)
  cd ~/Research/CROAM/Lib/grids
  mkdir gom
  cd gom
  mkdir ROMS/ WRF/
- Place grid.nc files for ROMS and WRF in ~/Research/CROAM/Lib/grids/gom
  cp ~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom-grid.nc ./
  cp ~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom/geo_em.d01.nc ./
- Create associated files (grid info) for ROMS and WRF
  Note that grid info files are named as "model-resolution_gridname*.dat"
  Since we'll use Manu's toolbox for this, check that ~/ROMS/Manu_toolbox/matlib/rnt/rnt_gridinfo.m contains the correct locations of the grid.nc files
  gridmask.m is not used since there's no interpolation needed between grids.
  cd ~/Research/CROAM/Lib/grids
  cp gen_grid.m gom/
  cd gom
  vi gen_grid.m
  rgn='gom';
  romsrgn='roms30_gom';
  wrfrgn='wrf30_gom';
  matlab
  gen_grid
  exit
- Make text file for tiling purposes
  No tiling in this case, so skip this. But below is an example if needed.

cd ~/Research/CROAM/Lib/grids/gom
vi gom_tile.txt
1

5. Initial, forcing and boundary files for ROMS and WRF

WRF requires boundary conditions that can be from GFS, Reanalysis, etc. Typically, we use NCEP Final Analysis (FNL from GFS) to set up the boundary conditions and initial state. If we don't explicitly give SST, WRF will use FNL data for surface forcing. But here, we shall use SST from ROMS.

ROMS can use boundary conditions from a variety of sources (including Levitus, SODA, OFES, etc). Initial state of ROMS can be taken from the spin up run. Forcing for ROMS comes from WRF, but dependent upon which options are chosen (bulk parameterization or not), WRF can provide the necessary variables needed for either computation.

a. WPS/WRF

We'll use WPS to create the the necessary files. If the data has a grib2 format, we 'll use ungrib.exe to create intermediate WPS format files. Then metgrid.exe to create the intermediate netcdf file.

- Download the data needed for prep BC and IC.
  You can download FNL data (grib2 format data) from http://www.mmm.ucar.edu/wrf/users/download/free_data.html
  Click link to http://dss.ucar.edu/datasets/ds083.2/data/
  Register your email
  For this study, pick data GRIB2 2010, Jan (2010Jan_grib.tar) , 6 hourly data.
- Store data in ~/Couple_WrfRoms/Info/WRFdata
  cd ~/Couple_WrfRoms/Info/WRFdata
  tar xvf 2010Jan_grib.tar
- Edit namelist.wps to begin processing of grib format files
  cd ~/Couple_WrfRoms/Model/WPS
  vi namelist.wps
  &ungrib
  out_format = 'WPS',
  prefix = '~/Couple_WrfRoms/Model/WPS/gom/GOM',
- Ensure Vtable is linked to Vtable.GFS
  ln -s ungrib/Variable_Tables/Vtable.GFS Vtable
- Create all the links to grib files (GRIBFILE.___) that are used for the run

link_grib.csh ~/Couple_WrfRoms/Info/WRFdata/Jan2010/fnl*

- Create intermediate WPS format files (GOM:YYYY-MM-DD-HH)
  ungrib.exe >& gom/ungribinventory.log
  mv ungrib.log gom/.
  rm GRIBFILE*
- Create the initial, boundary and SST forcing files
  This is not required because the coupler would automatically do it for you (Shell/Roms2Wrf.sh)
  Essentially what it does is the following:
  1) Creates SST WPS format file and fill with all zeros
  2) Creates intermediate netcdf file (met_em*.nc)
  3) Writes SST from ROMS onto met_em*.nc
  4) Makes the initial, boundary and forcing files (wrfinput_d01, wrfbdy_d01 and wrflowinp_d01) in ~/Couple_WrfRoms/Model/WRFV3/test/em_real
  5) If not on day one, initial file template is updated with values from restart file.
  To get step 2 right, be sure to update namelist.wps correctly.
  cd ~/Couple_WrfRoms/Model/WPS
  vi namelist.wps

```
&metgrid
 fg_name = '~/Couple_WrfRoms/Model/WPS/gom/GOM', '~/Couple_WrfRoms/Model/WPS/gom/SST'
 io_form_metgrid = 2,
 opt_output_from_metgrid_path = '~/Couple_WrfRoms/Model/WPS/gom',
```

b. ROMS

- Create forcing and initial .nc file template for ROMS
  cd ~/Research/CROAM/Lib/preparerun/ROMS
  mkdir gom/
  cd !$
  mkdir general_forcing/ coldstart/ bdry_clim/
  cd ../..
  cp create_bulk_forc_init.m ROMS/gom/general_forcing
  cp coldstart_init.m ROMS/gom/coldstart
  cp create_clim_bdry.m ROMS/gom/bdry_clim
  cd ROMS/gom/general_forcing/
  vi create_bulk_forc_init.m
  cd ~/Research/CROAM/Lib/preparerun/ROMS/gom/general_forcing
  nameit='gom';
  matlab
  create_bulk_forc_init

exit

- Create boundary files for ROMS

  cd ~/Research/CROAM/Lib/preparerun/ROMS/gom/bdry_clim
  vi create_clim_bdry.m
  nameit='roms30_gom';
  %nameit is the same as romsrgn
  nameit2='gom';
  %nameit2 is the same as gridname
  dataset=0; % 0=dataset for general clim and bdry that has been made from IRD toolbox
  %dataset = 1; % 1=WOA2001 (Uses IRD toolbox)
  %dataset = 2; % 2=SODA (Uses Manu's toolbox)
  %dataset = 3; % 3=Levitus (Uses Manu's toolbox)
  %dataset = 4; % 4=OFES (monthly output using Manu's toolbox)
  %if dataset = 4, use create_bry_from_clim.m
  BC_dir=['~/Research/CROAM/Lib/preparerun/ROMS/gom/bdry_clim/'];
  predir=['~/ROMS/IRD_toolbox/Roms_tools/Preprocessing_tools_test/gom/'];
  matlab
  create_clim_bdry
  exit

- Create very first initial file for ROMS from spin up run

  cd /Research/CROAM/Lib/preparerun/ROMS/gom/coldstart/
  scp usr@comp.cluster:~/Couple_WrfRoms/Model/ROMS/spinup_gom/avg_0010.nc ./
  One can use ncview to see which initial file to use, and which initial month to pick.
  vi coldstart_init.m
  cd ~/Research/CROAM/Lib/preparerun/ROMS/gom/coldstart
  grd=rnt_gridload('gom');
  initfile='./roms30_gom-spinup.nc';
  climfile='avg_0010.nc';
  rnc_CreateIniFile(grd,initfile);
  timeindex=1; %1 to length(t)=12 Jan-Dec
  matlab
  coldstart_init
  exit

6. Executables for WRF and ROMS

With the spin up running, we now prepare for the CROAM run.

a. WRF

Executable for WRF comes from ∼/Couple_WrfRoms/Model/WRFV3/test/em_real/wrf.exe. To run WRF, use the launch file (wrflaunch64) in ∼/Couple_WrfRoms/Shell

- Modify input file for WRF run
  Within this input file (namelist.input), you will provide domain and time specifications, physics packages, dynamical options, boundary controls, etc. For details on the parameters you can use in namelist.input, look in ∼/Couple_WrfRoms/Model/WRFV3/run/README.namelist
  cd ∼/Couple_WrfRoms/Model/WRFV3/test/em_real/
  vi namelist.input

```
 &time_control
 run_days                            = 0,
 run_hours                           = 24,
 run_minutes                         = 0,
 run_seconds                         = 0,
 start_year                          = 2010,
 start_month                         = 01,
 start_day                           = 19,
 start_hour                          = 00,
 start_minute                        = 00,
 start_second                        = 00,
 end_year                            = 2010,
 end_month                           = 01,
 end_day                             = 20,
 end_hour                            = 00,
 end_minute                          = 00,
 end_second                          = 00,
 interval_seconds                    = 21600
 input_from_file                     = .true.,
 history_interval                    = 180,
 frames_per_outfile                  = 1,
 restart                             = .false.,
 restart_interval                    = 1440,
 io_form_history                     = 2
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 2
 debug_level                         = 0
 auxinput4_inname = "wrflowinp_d<domain>",
```

```
auxinput4_interval = 360,
io_form_auxinput4 = 2
/
&domains
time_step                           = 180,
time_step_fract_num                 = 0,
time_step_fract_den                 = 1,
max_dom                             = 1,
s_we                                = 1,
e_we                                = 74,
s_sn                                = 1,
e_sn                                = 74,
s_vert                              = 1,
e_vert                              = 28,
p_top_requested                     = 5000,
num_metgrid_levels                  = 27,
num_metgrid_soil_levels             = 4,
dx                                  = 30000,
dy                                  = 30000,
grid_id                             = 1,
parent_id                           = 0,
i_parent_start                      = 1,
j_parent_start                      = 1,
parent_grid_ratio                   = 1,
parent_time_step_ratio              = 1,
feedback                            = 1,
smooth_option                       = 0
/
 &physics
mp_physics                          = 3,
ra_lw_physics                       = 1,
ra_sw_physics                       = 1,
radt                                = 30,
sf_sfclay_physics                   = 1,
sf_surface_physics                  = 2,
bl_pbl_physics                      = 1,
bldt                                = 0,
cu_physics                          = 1,
cudt                                = 5,
```

```
 isfflx                              = 1,
 ifsnow                              = 0,
 icloud                              = 1,
 surface_input_source                = 1,
 num_soil_layers                     = 4,
 sf_urban_physics                    = 0,
 maxiens                             = 1,
 maxens                              = 3,
 maxens2                             = 3,
 maxens3                             = 16,
 ensdim                              = 144,
 sst_update                          = 1,
 /
&fdda
 /
 &dynamics
 w_damping                           = 0,
 diff_opt                            = 1,
 km_opt                              = 4,
 diff_6th_opt                        = 0,
 diff_6th_factor                     = 0.12,
 base_temp                           = 290.
 damp_opt                            = 0,
 zdamp                               = 5000.,
 dampcoef                            = 0.2,
 khdif                               = 0,
 kvdif                               = 0,
 non_hydrostatic                     = .true.,
 moist_adv_opt                       = 1,
 scalar_adv_opt                      = 1,
 /
 &bdy_control
 spec_bdy_width                      = 5,
 spec_zone                           = 1,
 relax_zone                          = 4,
 specified                           = .true.,
 nested                              = .false.,
 /
&grib2
```

```
/
&namelist_quilt
nio_tasks_per_group = 0,
nio_groups = 1,
/
```

b. ROMS

This is very similar to the ROMS spin-up set up, except the application name is now GOM instead of SPINUP_GOM. All conducted in the linux machine.

- Create "apps.h" file.
  Similar to spinup_gom.h, but with some adjustments, as noted below for this case study. Recall, no sponge layer is used. Refer to SCOAR manual for implementing sponge layer.
  cd ~/Couple_WrfRoms/Model/ROMS/ROMS/Include
  cp spinup_gom.h gom.h
  vi gom.h
  #undef QCORRECTION
  #undef SCORRECTION
  #define BULK_FLUXES
  #define COOL_SKIN
  #define LONGWAVE_OUT
  #define EMINUSP
- Modify makefile, provide a name for ROMS application
  cd gom
  vi makefile
  ROMS_APPLICATION ?= GOM
- Now to make the ROMS executable file, oceanM will be created in ~/Couple_WrfRoms/Model/ROMS/
  cd ../..
  make
- Create input file (ocean_gom.in)
  Also pretty similar to ocean_spinupgom.in with some adjustments.
  cd ~/Couple_WrfRoms/Model/ROMS/ROMS/External
  cp ocean_spinupgom.in ocean_gom.in
  vi ocean_gom.in
  TITLE = GULF OF MEXICO
  MyAppCPP = GOM
  VARNAME = varinfo.dat

```
Lm == 71 ! Number of I-direction INTERIOR RHO-points
Mm == 71 ! Number of J-direction INTERIOR RHO-points
N == 30 ! Number of vertical levels

NtileI == 8 ! I-direction partition
NtileJ == 8 ! J-direction partition

NTIMES == 144
DT == 600.0d0
NDTFAST == 30

NRREC == 0
LcycleRST == T
NRST == 145

LDEFOUT == T
NHIS == 145
NDEFHIS == 0
NTSAVG == 1
NAVG == 144
NDEFAVG == 0
NTSDIA == 1
NDIA == 145
NDEFDIA == 0

DSTART = 0.0d0 ! days
TIDE_START = 0.0d0 ! days
TIME_REF = 0.0d0 ! yyyymmdd.dd

GRDNAME == ocean_grd.nc
ININAME == ocean_ini.nc
CLMNAME == ocean_clm.nc
BRYNAME == ocean_bry.nc

NFFILES == 1 ! number of forcing files
FRCNAME == ocean_frc.nc ! forcing file 1, grid 1
RSTNAME == ocean_rst.nc
HISNAME == ocean_his.nc
AVGNAME == ocean_avg.nc
```

APARNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/s4dvar.in
SPOSNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/stations.in
FPOSNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/floats.in
BPARNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/bioFasham.in
SPARNAM = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/sediment.in
USRNAME = ~/Couple_WrfRoms/Model/ROMS/ROMS/External/MyFile.dat

7. Folders and files in their appropriate places

- Archive folders (local machine)
  cd ~/storage
  mkdir CROAM_output
  cd !$
  mkdir gom/
  cd !$
  mkdir ROMS/ WRF/
  cd WRF
  mkdir avg/ init/ sst/
  cd ../ROMS
  mkdir avg/ forc/ init/
- Create folders to place files needed for the CROAM application run (LINUX machine)
  cd ~/Couple_WrfRoms/Info/templates
  mkdir gom/ gom/ROMS
  cd ~/Couple_WrfRoms/Lib/grids
  mkdir gom/
  cd !$
  mkdir ROMS/ WRF/
  cd ~/Couple_WrfRoms/Lib/exec
  mkdir ROMS/gom
- Create folder that would contain the scripts for the application run.
  cd ~/Couple_WrfRoms/Shell mkdir gom/ cp couple_Nday.sh gom/ cp changenamelistinput.sh gom/ cp changenamelistwps.sh gom/ cp writeRST2INIT.sh gom/ cp Roms2Wrf.sh gom/ cp wrflaunch64 gom/ cp Wrf2Roms_bulk.sh gom/ cp prepareROMS.sh gom/ cp uauo.sh gom/
- Edit the driver script according to your application needs.
  cd ~/Couple_WrfRoms/Shell/main_couple
  cp main_couple.sh main_couple_gom.sh
  vi main_couple_gom.sh
  YYYYS=2010 #start year

MMS=01 #start month
DDS=15 #start day
YYYYE=2010 #end year
MME=01 #end month
DDE=20 #end day
RESTART=no #restart option
LastNDay= #Model day for restart
gridname=gom #name of application
RGN=GOM #region name
wrfNCPU=64 #number of CPUs used for WRF
romsNCPU=64 #number of CPUs used for ROMS
Nameit_WRF=wrf30_gom # model, resolution, grid name
Nameit_ROMS=roms30_gom # model, resolution, grid name
BCFile=WOA01_month #Boundary conditions for ocean model
archive=yes #archive in local computer, not cluster
archive_dir_wrf=~/storage/CROAM_output/gom/WRF
archive_dir_roms=~/storage/CROAM_output/gom/ROMS
nd=30 #number of vertical layers in ocean model
ICsstFile=~/Couple_WrfRoms/Model/ROMS/spinup_$gridname/avg_0010.nc #Initial file to make initial SST
int_SST_nt=1 # time index in ICsstFile for making initial SST
inthr=6 # interval hours (converted to seconds) to add SST
filterSST=no #smoothing of SST fields at each coupling
needinterp=no #interpolation between ROMS and WRF grids
tiling=no #tiling between ROMS and WRF grids

- NOTE: At this point, you should check the rest of the shell scripts to make sure you've accounted for any changes.
- Transfer grid information files
  cd ~/Couple_WrfRoms/Lib/grids
  scp -r user@home.comp:~/Research/CROAM/Lib/grids/gom/ROMS ~/Couple_WrfRoms/Lib/grids/gom
  scp -r user@home.comp:~/Research/CROAM/Lib/grids/gom/WRF ~/Couple_WrfRoms/Lib/grids/gom
  If tiling was used, then we must also transfer the required file. Example,
  scp user@home.comp:~/Research/CROAM/Lib/grids/gom/gom-tile.txt ~/Couple_WrfRoms/Lib/grids/gom
- Transfer ROMS initial and template files
  cd ~/Couple_WrfRoms/Info/templates/gom/ROMS
  sftp user@home.comp
  cd ~/Research/CROAM/Lib/preparerun/ROMS/gom/coldstart
  get roms*-spinup.nc
  cd ../general_forcing

mget *.nc
exit

- Transfer ROMS files to run ocean model
  cd ~/Couple_WrfRoms/Model/ROMS/
  cp node_list ~/Couple_WrfRoms/Lib/exec/ROMS/gom/
  vi launch64
  /share/apps/mpich1/pgi/bin/mpirun -nolocal -np 64 -machinefile node_list oceanM ocean.in
  cp launch64 ~/Couple_WrfRoms/Lib/exec/ROMS/gom/
  cp oceanM ~/Couple_WrfRoms/Lib/exec/ROMS/gom/
  cp ROMS/External/ocean_gom.in ~/Couple_WrfRoms/Lib/exec/ROMS/gom/ocean_gom.in

- WRF executable has already been accounted for in ~/Couple_WrfRoms/Model/WRFV3/test/em_real . Launch file wrflaunch64 (in ~/Couple_WrfRoms/Shell) comes with the coupler and is ready for use without changes (unless you're changing the number of CPUs).
- Create a log dir for keep your log files
  cd ~/Couple_WrfRoms/Log
  mkdir gom_log

8. Running CROAM

Now at last we can run the model. Typically, you would want to run it on a background.
cd ~/Couple_WrfRoms/Shell/main_couple
main_couple_gom.sh >& ../../Log/gom_log/log1 &